PART - A

Dr. Homi Bhabha State University, Mumbai

HBSU

Barcode No. 1900162757

Do not write/Mark on Bar Code

(Read the Instructions given on the reverse side)
Use Blue / Black Ball Pen only to darken the appropriate circles. Do not fold, tear, wrinkle, staple or use whitener on the cover page of the answer book. Do not write or mark on the barcode and the timing tracks.

CORRECT METHOD ●○○○ WRONG METHOD

Supplement Booklet Information

Supplement Taken	Write the Supplement Barcode No.
Ⓨ ●	
If Yes, How Many Booklets ①②③④	

Confirm and Sign by Block Supervisor

11·12·19

Signature of Candidate	Candidate Seat Number
	2 0 1 9 2 1 9 5

600691

College Seal and Date

INSTITUTE OF SCIENCE MUMBAI

11 DEC 2019

Medium of Answer

1. English ○
2. Marathi ○
3. Other ○

PRN	2 0 1 9 0 0 1 6 9 9
Candidate Seat No.	2 0 1 9 2 1 9 5

Q.P.Code	Subject Code (printed on Hallticket)
0 3 4 1 4 7	0 3 1 0 6 4

Signature & Name of the Block Supervisor with Date	Signature of Chief Coordinator
11·12·19	

Exam Date	1 1 / 1 2 / 2 0 1 9	
Program Name	msc	
Program Code	Year	Semester
Subject Name		
Subject Code		

Part - B

Barcode No. 1900162757

Do not write/Mark on Bar Code

Exam Date :
Program Code & Name :
Subject Code & Name :
Year / Semester :

If Physically challenged : LD ○ PC ○ VI ○ Regular ○

Question wise marks given by Examiner

Q. No.	Marks	Q. No.	Marks
1		6	
2		7	
3		8	
4		9	
5		10	
		Total	

Name and Signature of Examiner with Date

Question wise marks given by Moderator

Q. No.	Marks	Q. No.	Marks
1		6	
2		7	
3		8	
4		9	
5		10	
		Total	

Name and Signature of Moderator with Date

Sr. No. 1900023251

INSTRUCTIONS TO CANDIDATES

1. Candidates should occupy the correct seat and write correct seat number and other details in the space provided for the purpose on the answer-books.
2. Candidates who are not in their seats by the time notified, will not as a rule be permitted to appear for the examination. The Senior Supervisor may at his/her discretion admit those who give him/her a satisfactory reason.
3. Each answer-book contains forty pages. Check whether the pages are properly numbered.
4. Candidates should write their answers in legible handwriting. They are warned that zero marks may be assigned to answers which cannot be assessed by the examiners owing to illegible handwriting.
5. Write on both sides of a page. Rough work where necessary, should be done on the last page in the space provided. No page should be left blank. Any such act shall be treated as unfair means.
6. Do not write anything in the Examiner & Moderator sheet (Part-B) & Re-Evaluator Sheet except Candidate details.
7. Do not damage or make any stray marks on the barcodes.
8. Candidates will not be permitted to leave the examination hall until half an hour after the question paper is distributed.
9. All answer-books supplied shall be returned whether written or blank. Nothing shall be written on the question-paper.
10. No sheet shall be torn from the provided answer-books nor shall additional papers attached to them.
11. Even if it is mentioned in question paper to write each section in separate answer book, if any paper / subject have multiple sections, **the candidate has to write all sections in one and the same answer book.**
12. A warning bell will be given ten minutes before the close of the examination. Candidates will not be allowed to leave the examination hall during the last ten minutes. At the final bell, they must stop writing and be ready to hand over their answer books to the Junior Supervisor. They should not leave their seats until answer-books from all candidates are collected by the Junior Supervisor.

UNFAIR MEANS IN THE EXAMINATIONS

13. **Candidates shall write the answers only with BLUE/BLACK ink Ball pen only. Use of any other Pen like Gel ink or Fountain ink or any other colour ink, will be treated as unfair means in terms of revealing of identity.**
14. Candidates are **forbidden to (i) bring any book, notes, scribbling papers, pages, Mobile phones/smart watches or any other similar devices.** (ii) speak or communicate in any manner to any other candidate, while the examination is in progress, and (iii) take with them any answer-book written or blank while leaving the examination hall. The supervisors/authorized persons are authorized to check the students.
15. A candidate who disobeys any instructions issued by the Senior/ Junior Supervisor or who is guilty or rude or disobedient behavior is liable for disciplinary action to be taken against him / her by the University.
16. Do not fold the answer book anywhere because it will be treated as unfair means in terms of revealing of identity.
17. Candidates suspected to be guilty of any of the aforesaid acts will be allowed to write their paper only after giving an undertaking in writing that the decision of the University in respect of the reported act of unfair means is binding on them/Exchange of writing materials, stencils, mathematical instruments, etc. is strictly prohibited. If candidates want anything, they should approach the Junior Supervisor without disturbing other candidates. However, they should not leave their seats on any account..
18. Any method to bribe the examiner/s by attaching currency notes or letters is strictly prohibited and will result in serious action being taken by the University
19. Seat number should be written only the space provided for the same. Candidate should not write his/her name in any part of the answer-book. **Writing Name, Seat No., Phone/Cell No., putting signature, use of religious invocation or any writing that is not relevant to the answers anywhere in the answer-book will be treated as attempts to reveal identity.**
20. Underlining of answers for focusing attention is permitted. However, use of varied inks, except for illustrations and figures must be avoided. DO NOT use symbol like encircling the question or using colour arrows for P.T.O. These will all be considered as attempt to readily identify the specific answer-book & will be treated as unfair means.

IT IS PRESUMED THAT CANDIDATE HAS READ ALL THE ABOVE INSTRUCTIONS.

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Space for Marks	Question No.	

Q.1) Quantum mechanics is the branch of physics where we studied about to tiny particle which deals with the wave mechanics.

Postulates:-

(i) ~~It~~ must be differential

(ii) ~~It~~ must be continus

(iii) ~~It~~ must be normalized

(iv) It must have a Singled value

(v) It must flow the norlized ~~Contrual~~ Condition from all space.

(vi) It must have $|\psi|^2$

(vii) the state of system must be defind by ψ

(viii) The probality of finding the particle is given by $|\psi|^2$

(ix) The probality of finding any particle is positive so wave function is given as $|\psi|^2$

(x) It must be Squre Integral.

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Space for Marks	Question No.	

(b) $|\psi_0\rangle = \frac{1}{\sqrt{2}}|\phi_1\rangle + \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ ... (Given

$|\psi_1\rangle = \frac{1}{\sqrt{3}}|\phi_1\rangle + \frac{i}{\sqrt{3}}|\phi_3\rangle$ .... (Given)

Soln:-

$|\psi_0\rangle = \frac{1}{\sqrt{2}}|\phi_1\rangle + \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ — (i)

$\langle\psi_0| = \frac{1}{\sqrt{2}}|\phi_1\rangle + -\frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ — (ii)

for normalise $\langle\psi_0|\psi_0\rangle = 1$

$\therefore \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}} - \frac{i}{2} \times \frac{i}{2} + \frac{1}{2} \times \frac{1}{2}$

$= \frac{1}{2} + \frac{1}{4} + \frac{1}{4}$

$= \frac{1}{2} + \frac{2}{4}$

$= \frac{1}{2} + \frac{1}{2}$

$= 1$

Hence $|\psi_0\rangle$ is normalised

Now;

$|\psi_1\rangle = \frac{1}{\sqrt{3}}|\phi_1\rangle + \frac{i}{\sqrt{3}}|\phi_3\rangle$ ... (from Given) — (i)

$\langle\psi_1| = \frac{1}{\sqrt{3}}|\phi_1\rangle + -\frac{i}{\sqrt{3}}|\phi_3\rangle$ — (ii)

$\therefore$ Now: For normalised condition

$\langle\psi_1|\psi_1\rangle = 1$

Space for Marks	Question No.

$\therefore \frac{1}{\sqrt{3}} \times \frac{1}{\sqrt{3}} - \frac{i}{\sqrt{3}} \times \frac{i}{\sqrt{3}}$

$\therefore \frac{1}{3} + \frac{1}{3}$

$\therefore \frac{2}{3} \neq 1$

$\therefore |\psi_1\rangle$ is not normalised

Here; $\langle\psi_0| = \frac{1}{\sqrt{2}}|\phi_1\rangle - \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ and ... (from 1)

$|\psi_1\rangle = \frac{1}{\sqrt{3}}|\phi_1\rangle + \frac{i}{\sqrt{3}}|\phi_3\rangle$ ... (from Given)

$\therefore \langle\psi_0|\psi_1\rangle = \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{3}} - \frac{i}{2} + \frac{i}{\sqrt{3}} \times \frac{1}{2}$

$= \frac{1}{\sqrt{6}} - \frac{i}{2} + \frac{i}{2\sqrt{3}}$

$= \frac{1}{\sqrt{6}} - i\left(\frac{1}{2} - \frac{1}{2\sqrt{3}}\right)$

$\boxed{\langle\psi_0|\psi_1\rangle = \frac{1}{\sqrt{6}} - i\left(\frac{\sqrt{3}-1}{2\sqrt{3}}\right)}$,

and

$\langle\psi_1| = \frac{1}{\sqrt{3}}|\phi_1\rangle - \frac{i}{\sqrt{3}}|\phi_3\rangle$ $\quad |\psi_0\rangle = \frac{1}{\sqrt{2}}|\phi_1\rangle + \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$

$\therefore \langle\psi_1|\psi_0\rangle = \frac{1}{\sqrt{6}} + \frac{i}{2} - \frac{i}{2\sqrt{3}}$

$= \frac{1}{\sqrt{6}} + i\left(\frac{1}{2} - \frac{1}{2\sqrt{3}}\right)$

$\boxed{\langle\psi_1|\psi_0\rangle = \frac{1}{\sqrt{6}} + i\left(\frac{\sqrt{3}-1}{2\sqrt{3}}\right)}$

Space for Marks	Question No.	START WRITING HERE
	(3)	$V(x) = \infty \quad x<0$ and $x>a$
		$= -V_0 \quad 0<x<\frac{a}{2}$

<u>Solution:-</u>

Here $\psi(x) = \sqrt{\frac{2}{a}}\sin\left(\frac{n\pi x}{a}\right)$

Now 1st order correction is given as

~~$E_n^{(1)} = \langle \psi_n^{(0)} | H' | \psi_n^{(0)} \rangle$~~

$$E_n^{(1)} = \int_{-\infty}^{\infty} \psi_n^{*(0)} H' \psi_n^{(0)}\, dx$$

$$= \int_0^a \sqrt{\frac{2}{a}}\sin\left(\frac{n\pi x}{a}\right) \times (-V_0) \sqrt{\frac{2}{a}}\sin\left(\frac{n\pi x}{a}\right) dx$$

$$= \frac{2}{a}(-V_0)\int_0^a \sin^2\left(\frac{n\pi x}{a}\right) dx$$

$$= \frac{2}{a}(-V_0)\int_0^a \frac{1-\cos\left(\frac{2n\pi x}{a}\right)}{2}\, dx$$

$$= -\frac{V_0}{a}\int_0^a 1-\cos\left(\frac{2n\pi x}{a}\right) dx$$

$$= -\frac{V_0}{a}\left[\int_0^a 1\,dx - \int_0^a \cos\left(\frac{2n\pi x}{a}\right) dx\right]$$

$$= -\frac{V_0}{a}\left[x\right]_0^a - \left[\sin\left(\frac{2n\pi x}{a}\right)\times\frac{a}{2n\pi}\right]_0^a$$

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Space for Marks	Question No.	

$$\therefore \; -\frac{V_0}{a}\left[x\right]_0^a - \left[\sin\left(\frac{2n\pi a}{a}\right)\times\frac{a}{2n\pi} - \sin(0)\times\frac{a}{2n\pi}\right]$$

$$\therefore \; -\frac{V_0}{a}\left[a-0\right] - 0$$

$$= -\frac{V_0}{a}(a)$$

$$= -V_0$$

$$\therefore \boxed{E_n^{(1)} = -V_0}$$

(c) Soln:

$$\hat{H}_0 = \begin{bmatrix} E_0+E & 0 \\ 0 & E_0-E \end{bmatrix} \quad \text{and} \quad H' = \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix}$$

Soln:

here $|H' - E^n I| = 0$

$$\therefore \left| \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix} - E_n^{(1)} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \right| = 0$$

$$\therefore \left| \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix} - \begin{bmatrix} E_n^{(1)} & 0 \\ 0 & E_n^{(1)} \end{bmatrix} \right| = 0$$

$$\therefore \begin{vmatrix} -E_n^{(1)} & A \\ A & -E_n^{(1)} \end{vmatrix} = 0$$

$$\therefore (E_n^{(1)})^2 - A^2 = 0$$

$$\therefore (E_n^{(1)})^2 = A^2$$

$$\therefore \boxed{E_n^{(1)} = \pm A}$$

1st Order Correction of Energy

For 2nd Order

$$E_n^{(2)} = \frac{\langle \psi_{m(1)} | H' | \psi_n^{(1)} \rangle}{E_n^{(1)} - E_m^{(1)}}$$

$$E_n^{(2)} = \frac{A^2}{2\lambda}$$

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Space for Marks	Question No.	

(5)

(a) It is an mathematical term used as the notation in the Quantum meechanics as the wave function Such that

$$\delta(x) = 0 \quad x \neq 0$$
$$= \infty \quad x = \infty$$

on changing the scale

$$\delta(x - x_0) = 0 \quad x \neq x_0$$
$$= \infty \quad x = 0$$

Here $\delta(x)\,\delta(x-x_0) = 1$

Properties

(i) $\int_{-\infty}^{\infty} \delta(x)\,\delta(x-x_0) = 1$

(ii) $\int_{-\infty}^{\infty} \delta(x)\,\delta(x-x_0) = f(x_0)$

(i) $\int_{-\infty}^{\infty} f(x)\,\delta(x-c) = f(c)$

as c lies between a and b

(ii) $\int_{-\infty}^{\infty} f(x)\,\delta(x-c) = 0$

as c does not lies in between a and b

(iii) $\delta(ax) = \frac{1}{|a|}\delta(x)$

(iv) $\delta(-x) = \delta(x)$

(v) $\frac{d}{dx} f(x) = \delta(x)$

(vi) $x \cdot \delta(x) = 0$

(vii) $\delta(a-x)\,\delta(x-b) = \delta(a-b)$

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Space for Marks	Question No.	
	(viii)	$\delta(a-b) = \delta(b-a)$
	(ix)	$\int_{-\infty}^{\infty} \delta(x) = 1$
	(x)	$\int_{-\infty}^{\infty} f(x)\,\delta(x) = 1$

(c) Solnº:

$$\hat{x} = \left(\frac{\hbar}{2m\omega}\right)^{1/2} (a + a^{+})$$

External perturbation $H' = bx$

Now,

1st Order Correction to the Energy of the Oscillator is given as

$$E_n^{(1)} = \langle \psi_n^{(0)} | H' | \psi_n^{(0)} \rangle$$

$$= \langle \psi_n^{(0)} | b\hat{x} | \psi_n^{(0)} \rangle$$

$$= \langle \psi_n^{(0)} | \left(\frac{\hbar}{2m\omega}\right)^{1/2} b \,(a+a^{+}) | \psi_n^{(0)} \rangle$$

$$= \left(\frac{\hbar}{2m\omega}\right)^{1/2} b \langle \psi_n^{(0)} | (a + a^{+}) | \psi_n^{(0)} \rangle$$

$$= \left(\frac{\hbar}{2m\omega}\right)^{1/2} b \langle \psi_n^{(0)} | (a + a^{+}) | \psi_n^{(0)} \rangle$$

$E_n^{(1)} = 0$ //

as $(a + a^{+}) = 0$

lea

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Space for Marks	Question No.	

(Q.2) (c)

we have Eqution

$H\psi = E\psi$

$L_z\psi = c\psi$

c is any constant

$L_z\psi = \frac{\hbar}{i}\frac{\partial}{\partial\phi}$

$\therefore \frac{\hbar}{i}\frac{\partial\psi}{\partial\phi} = c\psi$ — (3)

$\therefore \frac{\partial\psi}{\psi} = \frac{ci}{\hbar}\partial\phi$

Integration

$\log\psi = \frac{c\phi}{i\hbar}$

$\therefore \psi = f(r,\theta)e^{ic\phi/\hbar}$

Incrasing ϕ by 2π

$f(r,\theta)e^{ic\phi/\hbar} = f(r,\theta)e^{ic(\phi+2\pi)/\hbar}$

$f(r,\theta)e^{ic\phi/\hbar} = f(r,\theta)e^{ic\phi/\hbar}\cdot e^{2\pi ic/\hbar}$

$= 1$

$m = \hbar c$

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here

$L_z = C$ .. (from i) and $C = \frac{\hbar}{m}$

$\therefore \boxed{L_z = m\hbar}$

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Space for Marks	Question No.	

(d) $(\sigma\cdot A)(\sigma\cdot B) = A\cdot B + i\sigma(A\times B)$

$\sigma = \sigma_x\hat{i} + \sigma_y\hat{j} + \sigma_z\hat{k}$

$A = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

$B = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$

$L\cdot h\cdot s = (\sigma\cdot A)(\sigma\cdot B)$

$= [(\sigma_x\hat{i} + \sigma_y\hat{j} + \sigma_z\hat{k})\cdot(A_x\hat{i} + A_y\hat{j} + A_z\hat{k})]\cdot$
$[(\sigma_x\hat{i} + \sigma_y\hat{j} + \sigma_z\hat{k})\cdot(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})]$

$= \cancel{[(\sigma_x\hat{i} + A_x\hat{i})\ (\sigma_y\hat{j} + A_y\hat{j})}$

$= [\sigma_x\hat{i} + A_x\hat{i}) + (\sigma_y\hat{j} + A_y\hat{j}) + (\sigma_z\hat{k} + A_z\hat{k})]$
$[(\sigma_x\hat{i} + B_x\hat{i}) + (\sigma_y\hat{i} + A_y\hat{j}) + (\sigma_z\hat{k} + A_z\hat{k})]$

$= [(\sigma_x + A_x)\hat{i} + (\sigma_y + A_y)\hat{j} + (\sigma_z + A_z)\hat{k}]\cdot$
$[(\sigma_x + B_x)\hat{i} + (\sigma_y + B_y)\hat{j} + (\sigma_z + B_z)k]$

$= \cancel{A_x\hat{i} + B_x}$

$= [(A_x\hat{i} + A_y\hat{j} + A_z\hat{k})\cdot(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})]$
$+ i[\sigma_x\hat{i}\, A_x\hat{i}\times B_x\hat{i} + \sigma_y\hat{j}\, A_y\hat{j}\times B_y\hat{j} + \sigma_z\hat{k}\, A_z\hat{k}\times A_z\hat{k}$

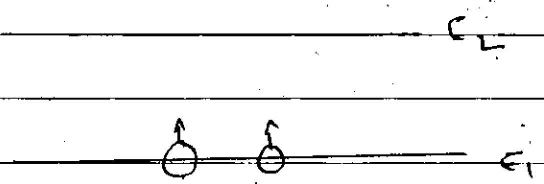
$= (A\cdot B) + i\sigma(A_x\hat{i}\times B_x\hat{i} + A_y\hat{j} + B_y\hat{j} + A_z\hat{k}\times A_z\hat{k})$

$= (A\cdot B) + i\sigma(A\times B)$

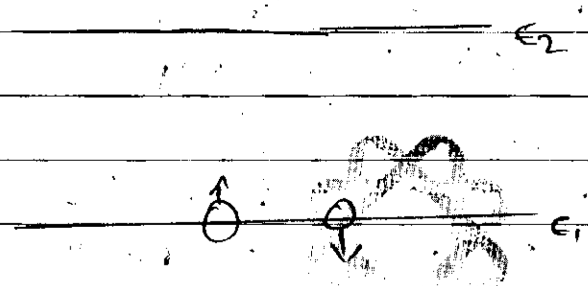
$\therefore = R\cdot h\cdot s$

$\therefore (\sigma\cdot A)(\sigma\cdot B) = A\cdot B + i\sigma(A\times B)$

(Q·4)



Symmetric wave function



Anti Symmetric wave function

fro Symmetric wave function

$$\psi_{sym} = \frac{1}{\sqrt{2}}\left(\psi_{(1)}\ \psi_{(2)} + \psi_{(2)} \cdot \psi_{(1)} \right)$$

$$\psi_{Antisym} = \frac{1}{\sqrt{2}}\left(\psi_{(1)}\psi_{(2)} - \psi_{(2)} - \psi_{(1)} \right.$$

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Space for Marks	Question No.	
	(Q.4)	Spilliting and shiting of the partile is known as Scattering.
	(d)	Elastic Scattering :- Elastic Scattering in an Scattering in which the initial Energy is Equal to the final Energy. kinetic Energy is not changed
		Inelastic Scattering: Inelastic Scattering is an Scattering in which initial Energy is not Equal to the final Energy. Here the kinetic Energy is changed
		Differential Scattering Cross Section : It is an Scattering which is Equal to the Elastic and Inelastic Scattering which on differentiating we get the Solid angle which is Same.
		Total Scattering Cross Section :- It is the total Scattering which is Obtain due to the Inelastic Scattering and the Elastic Scattering.

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Space for Marks	Question No.	
	Q.17 (c)	$\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n x}{L}\right)$ ... (given)

The probability of finding particle is given as $|\psi|^2$

Here
$$\int_0^{L/2} \frac{2}{L} \sin^2\left(\frac{n x}{L}\right) dx = \frac{2}{L} \int_0^{L/2} \sin^2\left(\frac{n x}{L}\right) dx$$

$$= \frac{2}{L} \int_0^{L/2} \left[1 - \cos\left(\frac{2nx}{L}\right)\right] dx$$

$$= \frac{2}{L} \left[\int_0^{L/2} 1\, dx - \int_0^{L/2} \cos\left(\frac{2nx}{L}\right) dx\right]$$

$$= \frac{2}{L} \left\{\left[x\right]_0^{L/2} - \left[\sin\left(\frac{2nx}{L}\right) \times \left(\frac{L}{2n}\right)\right]_0^{L/2}\right\}$$

$$= \frac{2}{L}\left[\frac{L}{2}\right] - 0$$

$$= 1$$

∴ Hence the probability of $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n x}{L}\right)$

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Space for Marks	Question No.	
	(Q.3) (d)	**Sol^n:**

Trail wave function is given by $\psi = A x(a-x)$

Here normalised condition

$\int_{-\infty}^{\infty} \psi^* \psi \, dx = 1$

$\therefore \int_0^a A x(a-x) \cdot A x(a-x) dx = 1$

$\therefore \int_0^a A^2 (x^2 (a-x)^2) dx = 1$

$\therefore A^2 \int_0^a x^2 (a-x)^2 dx = 1$

$\therefore A^2 \int_0^a x^2 [a^2 - 2ax + x^2] dx = 1$

$\therefore A^2 \int_0^a (x^2 a^2 - 2ax^3 + x^4) dx = 1$

$\therefore A^2 \left[\int_0^a x^2 a^2 dx - 2a \int_0^a x^3 dx + \int_0^a x^4 dx \right] = 1$

$\therefore A^2 \left\{ a^2 \int_0^a x^2 dx - 2a \int_0^a x^3 dx + \int_0^a x^4 dx \right\} = 1$

$\therefore A^2 \left\{ a^2 \left[\frac{x^3}{3}\right]_0^a - 2a \left[\frac{x^4}{4}\right]_0^a + \left[\frac{x^5}{5}\right]_0^a \right] = 1$

$A^2 \left[\frac{a^2 a^3}{3} - \frac{2a a^3}{3} + \frac{a^5}{5} \right] = 1$

$A^2 \left(\frac{a^5}{3} - \frac{2a^4}{3} + \frac{a^5}{5} \right) = 1$

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Space for Marks	Question No.	

$$A^2\left(\frac{a^5}{3}+\frac{a^5}{5}-\frac{2a^4}{3}\right)=1$$

$$A^2\left(\frac{5a^5+3a^5}{15}-\frac{2a^4}{3}\right)=1$$

$$A^2\left(\frac{8a^5}{15}-\frac{2a^4}{3}\right)=1$$

$$A^2 a^4\left(\frac{8a}{15}-\frac{1}{3}\right)=1$$

$$A^2 a^4\left(\frac{24a-15}{45}\right)=1$$

$$A^2=\frac{45}{(24a-15)a^4}$$

$$\boxed{A=\sqrt{\frac{45}{(24a-15)}\times a^2}}$$

$$\therefore \psi=\sqrt{\frac{45}{24a-15}\times a^2}\; x(a-x) \quad \text{——— (1)}$$

Now:-

$\langle H\rangle = \langle\psi|H|\psi\rangle$

where $H=-\frac{\hbar}{2m}\frac{d^2}{dx^2}+\frac{1}{2}m\omega x^2$

$\therefore$

$$\therefore A^2\left(\frac{a^2a^3}{3}-\frac{2a\,a^4}{4}+\frac{a^5}{5}\right)=1$$

$$A^2\left\{\frac{a^5}{3}-\frac{2a^5}{4}+\frac{a^5}{5}\right\}=1$$

$$A^2a^5\left(\frac{1}{3}-\frac{2}{4}+\frac{1}{5}\right)=1$$

Space for Marks	Question No.

$$A^2 a^5 \left(\frac{1}{30}\right) = 1$$

$$\therefore A^2 = \frac{30}{a^5}$$

$$\therefore \boxed{A = \sqrt{\frac{30}{a^5}}} \text{ —— }$$

Now; $\psi = \sqrt{\frac{30}{a^5}}\, x(a-x)$

$$= \sqrt{\frac{30}{a^5}}\, x\,(a-x) \text{ —— } (1)$$

Now; $\langle H \rangle = \langle \psi | H | \psi \rangle$ where $H = \frac{-\hbar}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2$

$$\therefore = \langle \psi | -\frac{\hbar}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2 | \psi \rangle$$

$$= -\frac{\hbar^2}{2m}\langle \psi | \frac{d^2}{dx^2} | \psi \rangle + \frac{1}{2}m\omega^2 \langle \psi | x^2 | \psi \rangle \text{ —— } (11)$$

Now, from eq (11) 1st term

$$\therefore -\frac{\hbar^2}{2m}\langle \psi | \frac{d^2}{dx^2} | \psi \rangle = -\frac{\hbar^2}{2m}\left\langle \sqrt{\frac{30}{a^5}}\, x(a-x) \cdot \frac{d}{dx^2} \sqrt{\frac{30}{a^5}}\, x(a-x) \right\rangle$$

$$= -\frac{\hbar^2}{2m}\left\langle \sqrt{\frac{30}{a^5}}\, x(a-x) \cdot \sqrt{\frac{30}{a^5}}(-2) \right\rangle$$

$$= +\frac{\hbar^2}{2m}\left\langle \frac{30}{a^5}\, 2x(a-x) \right\rangle \text{ —— } (11)$$

2nd term in eq (11)

$$\frac{1}{2}m\omega^2 \langle \psi | x^2 | \psi \rangle = \frac{30}{a^5}\, x^2(a-x)^2 \times x^2$$

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$$= \frac{30}{a^5} x^4 (a-x)^2$$

$$= \frac{30}{a^5} x^4 (a^2 - 2ax + x^2)$$

$$= \frac{30}{a^5} (x^4 a^2 - 2ax^5 + x^6)$$

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Program Code & Name :.....................................

Subject Code & Name :.....................................

Year / Semester :.....................................

Questionwise Marks given by Re-Evaluator

Q. No.	Marks	Q. No.	Marks
1		6	
2		7	
3		8	
4		9	
5		10	
		Total	

Name & Signature of Re-Evaluator with Date